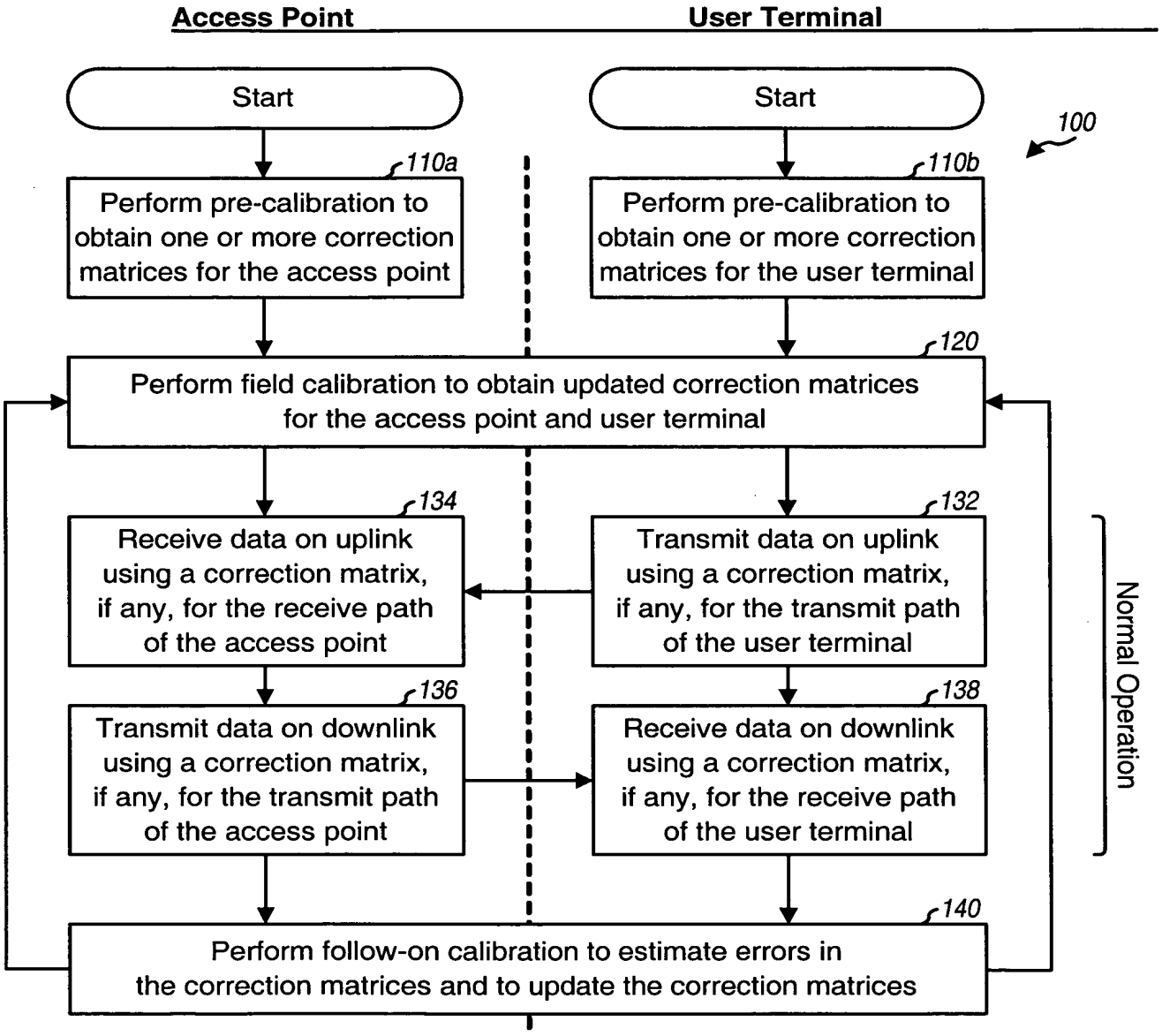
Access Point
User Terminal
Start
Start
100
110a
110b
Perform pre-calibration to obtain one or more correction matrices for the access point
Perform pre-calibration to obtain one or more correction matrices for the user terminal
120
Perform field calibration to obtain updated correction matrices for the access point and user terminal
134
132
Receive data on uplink using a correction matrix, if any, for the receive path of the access point
Transmit data on uplink using a correction matrix, if any, for the transmit path of the user terminal
136
138
Transmit data on downlink using a correction matrix, if any, for the transmit path of the access point
Receive data on downlink using a correction matrix, if any, for the receive path of the user terminal
140
Perform follow-on calibration to estimate errors in the correction matrices and to update the correction matrices
Normal Operation

FIG. 1

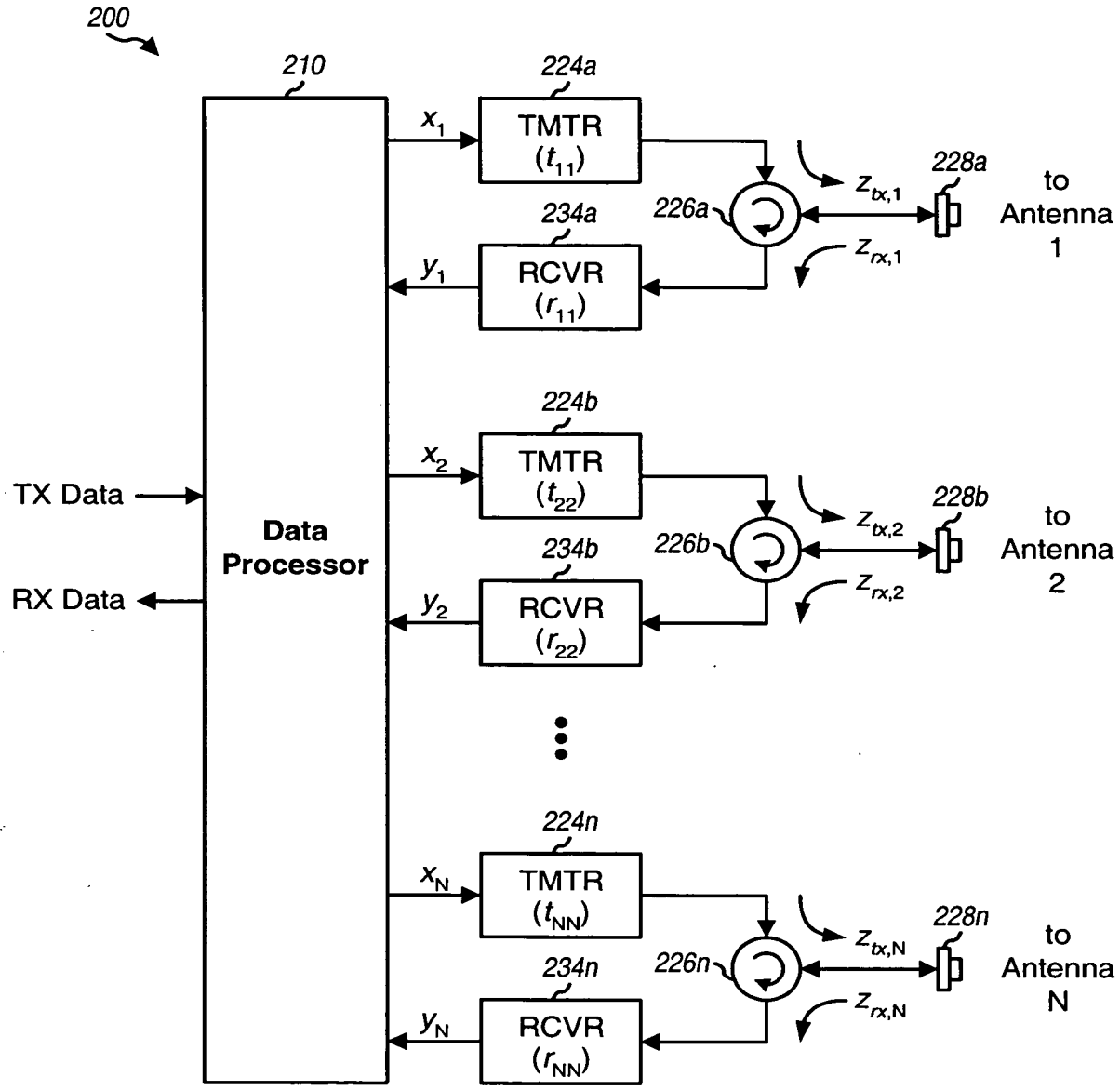
200
210
Data Processor
TX Data
RX Data
224a
TMTR (t_{11})
x_1
234a
RCVR (r_{11})
y_1
226a
$z_{tx,1}$
$z_{rx,1}$
228a
to Antenna 1
224b
TMTR (t_{22})
x_2
234b
RCVR (r_{22})
y_2
226b
$z_{tx,2}$
$z_{rx,2}$
228b
to Antenna 2
224n
TMTR (t_{NN})
x_N
234n
RCVR (r_{NN})
y_N
226n
$z_{tx,N}$
$z_{rx,N}$
228n
to Antenna N

FIG. 2

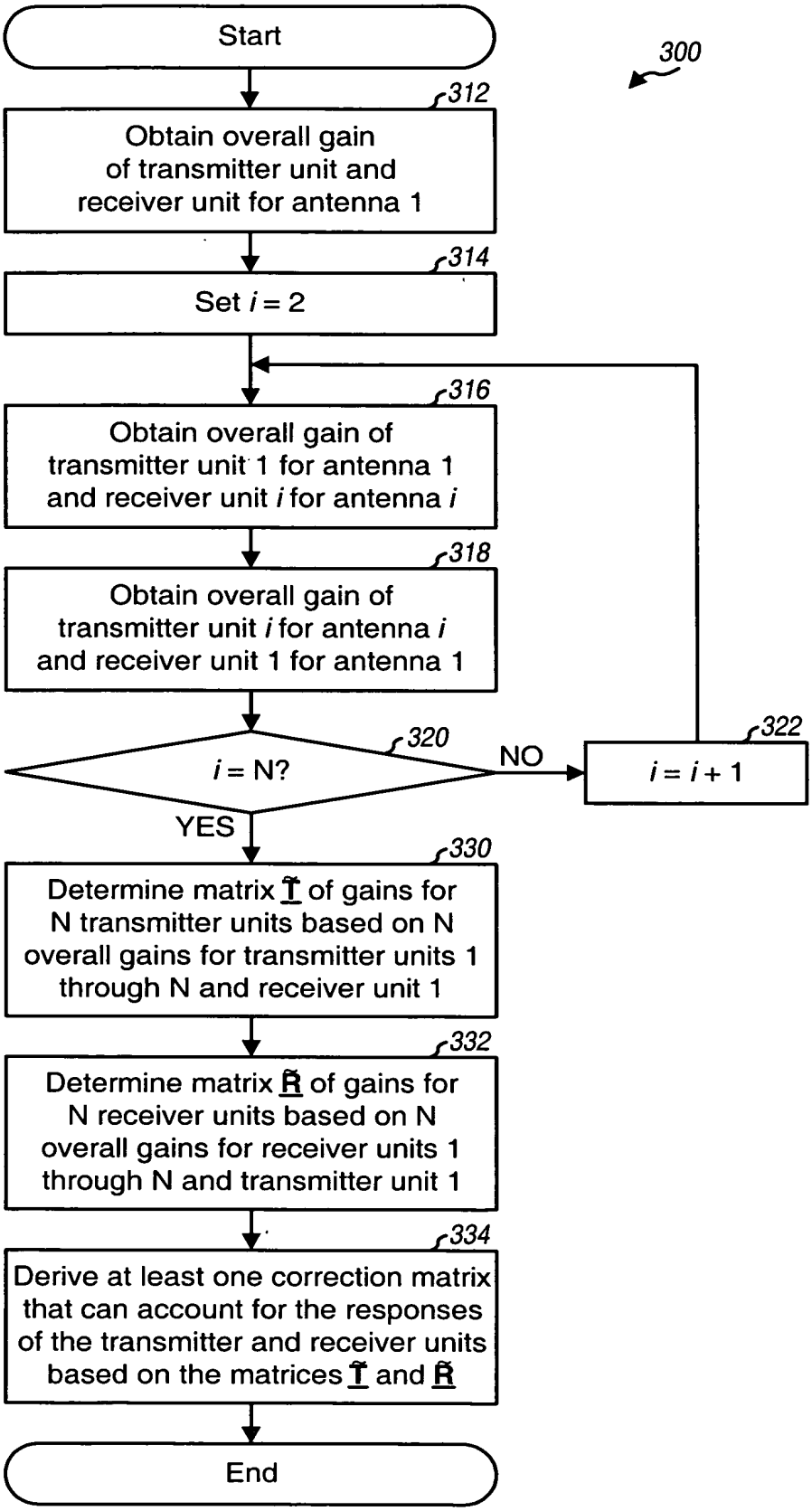
Start
300
312
Obtain overall gain of transmitter unit and receiver unit for antenna 1
314
Set i = 2
316
Obtain overall gain of transmitter unit 1 for antenna 1 and receiver unit i for antenna i
318
Obtain overall gain of transmitter unit i for antenna i and receiver unit 1 for antenna 1
320
i = N?
NO
322
i = i + 1
YES
330
Determine matrix T of gains for N transmitter units based on N overall gains for transmitter units 1 through N and receiver unit 1
332
Determine matrix R of gains for N receiver units based on N overall gains for receiver units 1 through N and transmitter unit 1
334
Derive at least one correction matrix that can account for the responses of the transmitter and receiver units based on the matrices T and R
End

FIG. 3

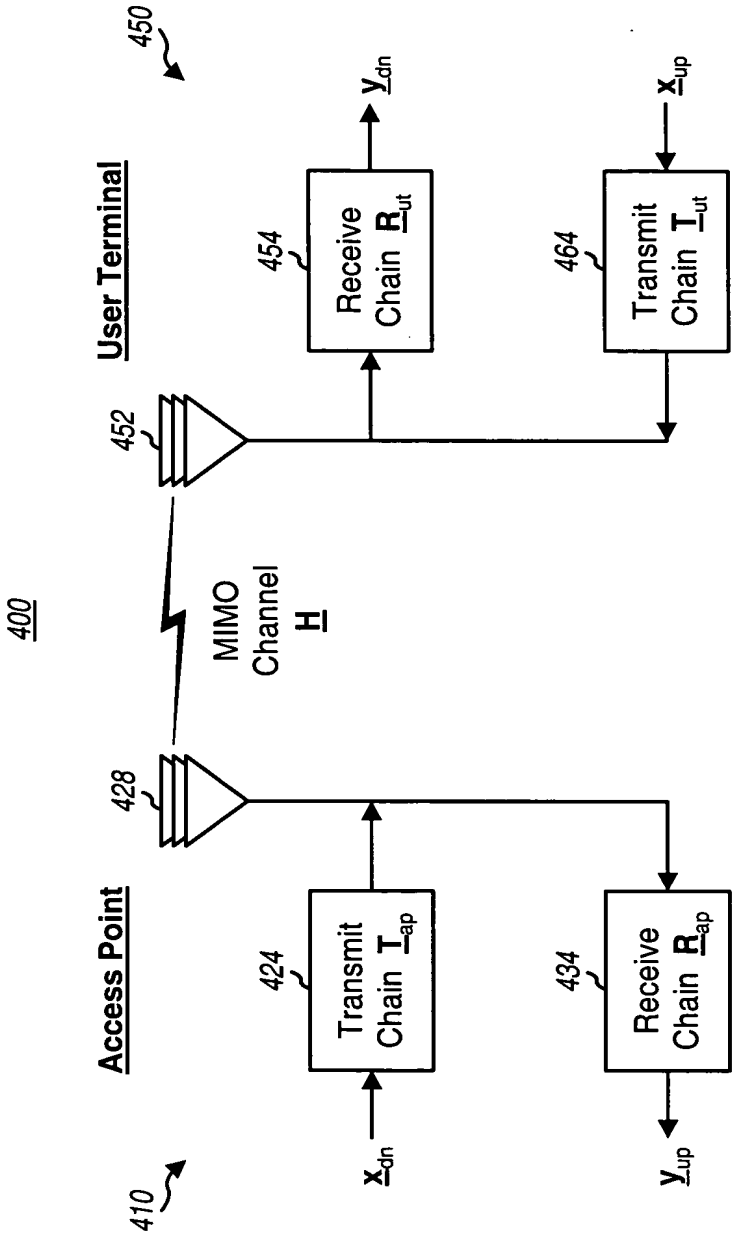
400
410
Access Point
User Terminal
450
428
452
MIMO
Channel
H
424
Transmit
Chain T_ap
434
Receive
Chain R_ap
454
Receive
Chain R_ut
464
Transmit
Chain T_ut
x_dn
y_up
y_dn
x_up

FIG. 4

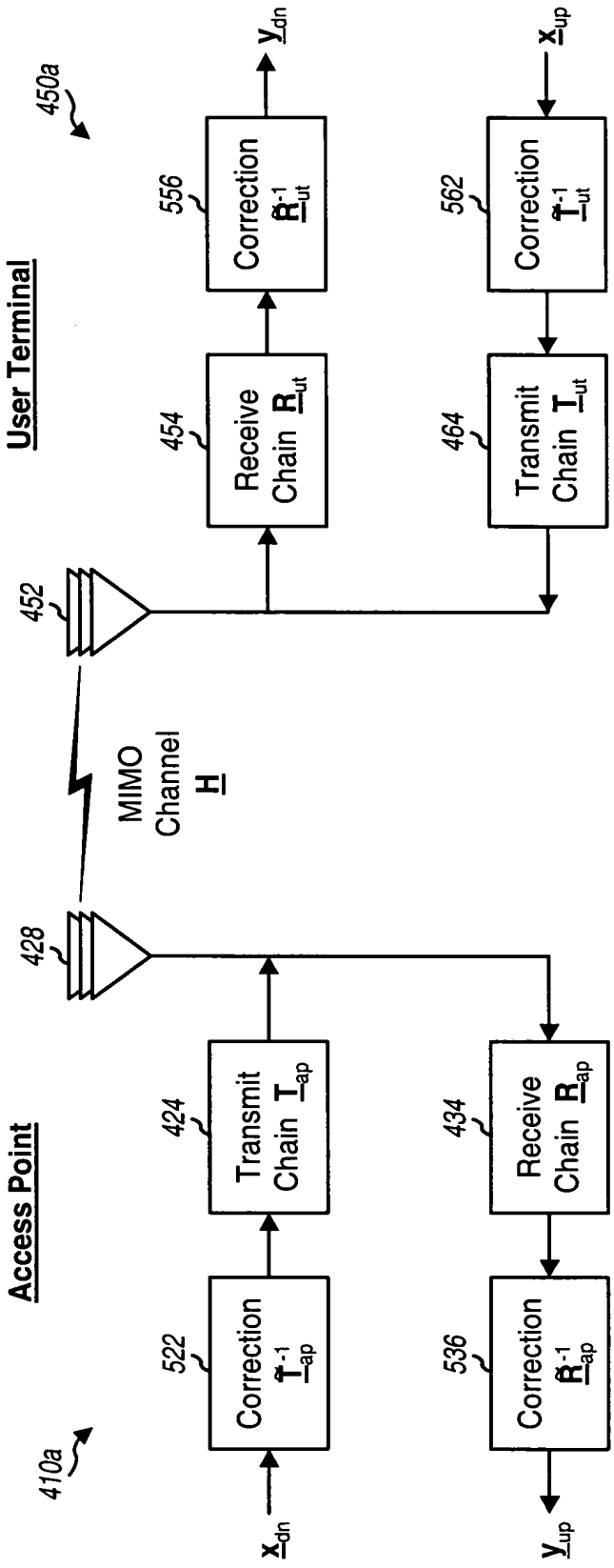
User Terminal
450a
556
Correction
$\underline{\hat{R}}_{ut}^{-1}$
$\underline{y}_{dn}$
562
Correction
$\underline{\hat{T}}_{ut}^{-1}$
$\underline{x}_{up}$
454
Receive
Chain $\underline{R}_{ut}$
464
Transmit
Chain $\underline{T}_{ut}$
452
MIMO
Channel
$\underline{H}$
428
Access Point
424
Transmit
Chain $\underline{T}_{ap}$
434
Receive
Chain $\underline{R}_{ap}$
522
Correction
$\underline{\hat{T}}_{ap}^{-1}$
536
Correction
$\underline{\hat{R}}_{ap}^{-1}$
410a
$\underline{x}_{dn}$
$\underline{y}_{up}$

FIG. 5

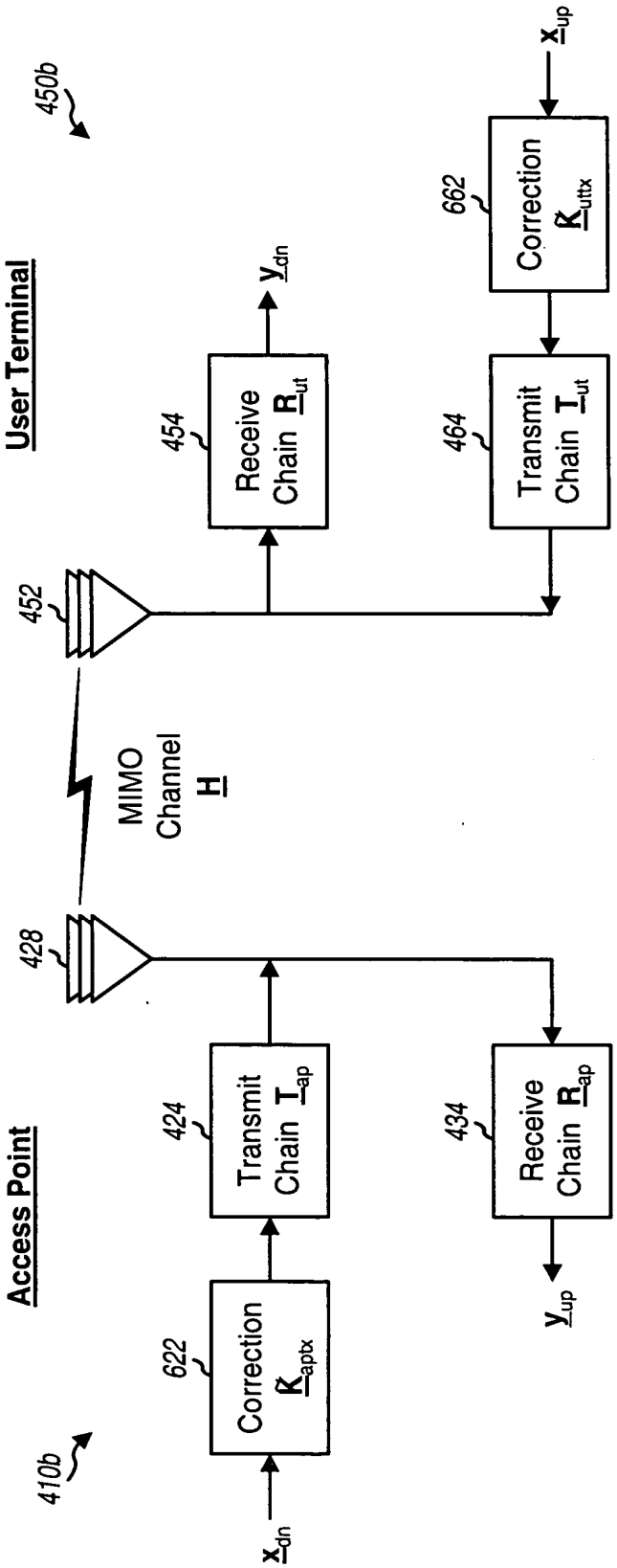
450b
User Terminal
662
Correction
$\underline{K}_{uttx}$
$\underline{x}_{up}$
454
Receive
Chain $\underline{R}_{ut}$
$\underline{y}_{dn}$
464
Transmit
Chain $\underline{T}_{ut}$
452
MIMO
Channel
$\underline{H}$
428
Access Point
424
Transmit
Chain $\underline{T}_{ap}$
434
Receive
Chain $\underline{R}_{ap}$
$\underline{y}_{up}$
622
Correction
$\underline{K}_{aptx}$
410b
$\underline{x}_{dn}$

FIG. 6

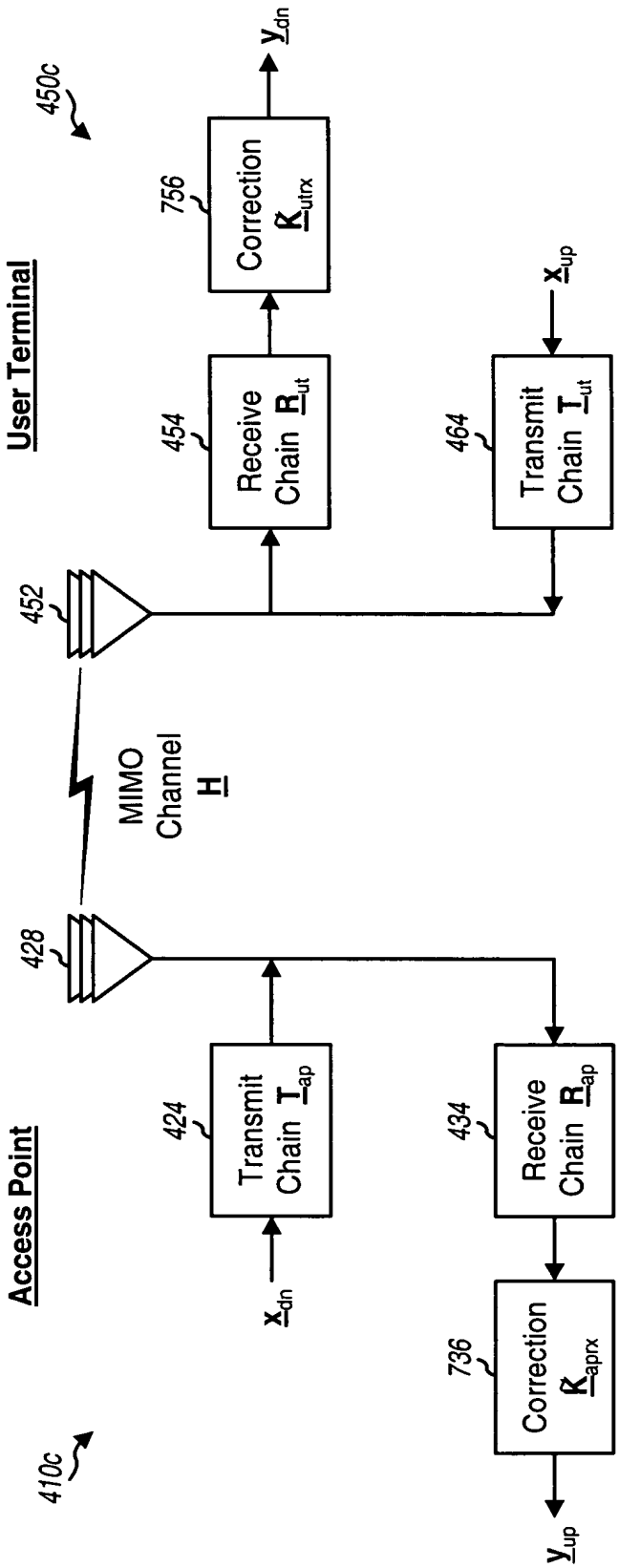
User Terminal
450c
756
Correction
$\underline{K}_{utrx}$
$\underline{y}_{dn}$
454
Receive
Chain $\underline{R}_{ut}$
464
Transmit
Chain $\underline{T}_{ut}$
$\underline{x}_{up}$
452
MIMO
Channel
$\underline{H}$
428
Access Point
424
Transmit
Chain $\underline{T}_{ap}$
434
Receive
Chain $\underline{R}_{ap}$
$\underline{x}_{dn}$
736
Correction
$\underline{K}_{aprx}$
410c
$\underline{y}_{up}$

FIG. 7

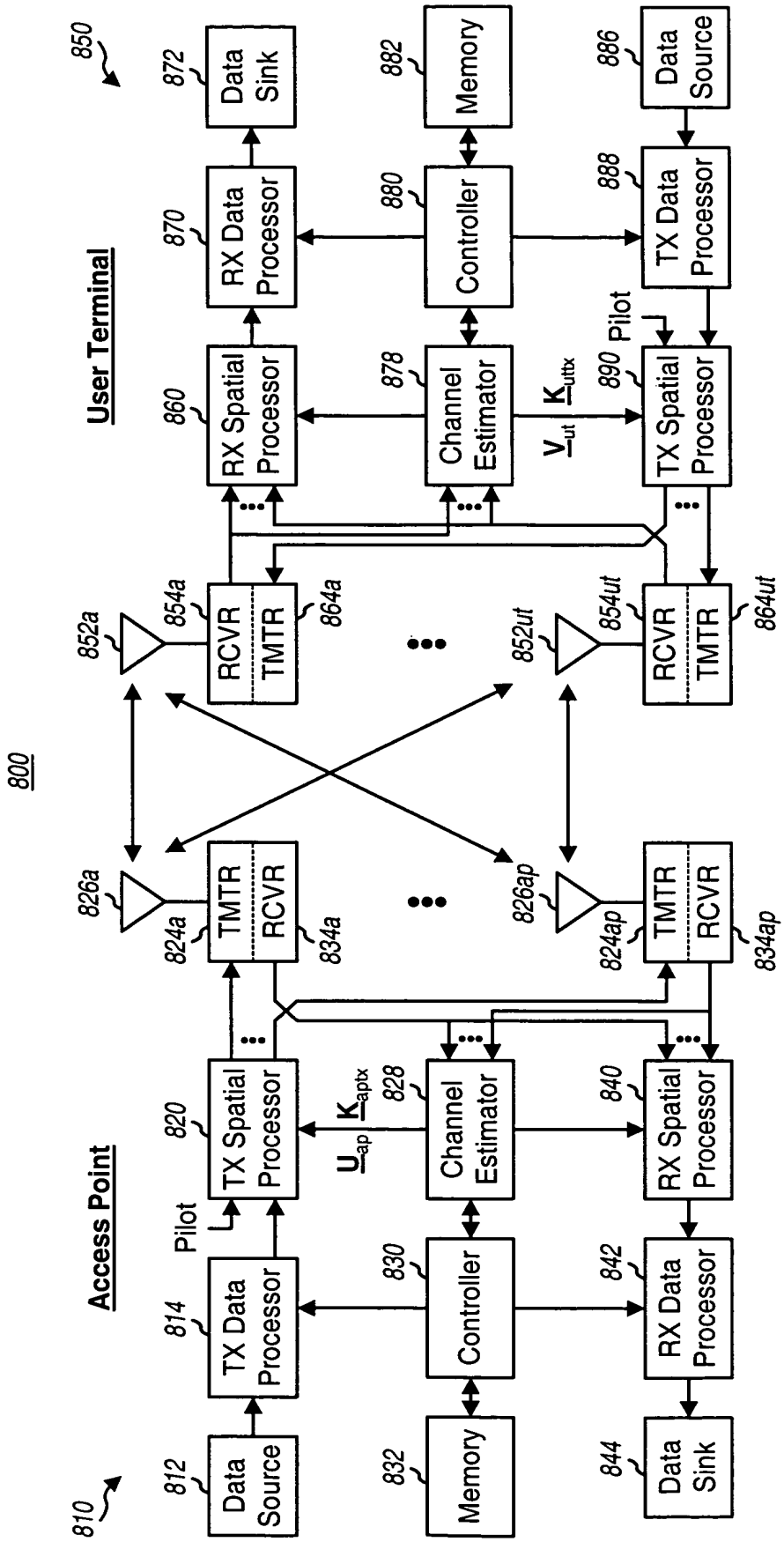
800
810
Access Point
812
Data Source
814
TX Data Processor
Pilot
820
TX Spatial Processor
824a
TMTR
RCVR
826a
834a
824ap
826ap
834ap
828
Channel Estimator
830
Controller
832
Memory
840
RX Spatial Processor
842
RX Data Processor
844
Data Sink
850
User Terminal
852a
854a
RCVR
TMTR
864a
852ut
854ut
864ut
860
RX Spatial Processor
870
RX Data Processor
872
Data Sink
878
Channel Estimator
880
Controller
882
Memory
890
Pilot
TX Spatial Processor
888
TX Data Processor
886
Data Source

FIG. 8